OVRO 40m blazar monitoring program: Understanding the relationship between 15 GHz radio variability properties and gamma-ray activity in blazars

Walter Max-Moerbeck on behalf of the OMG

OMG: OVRO 40m Monitoring Group

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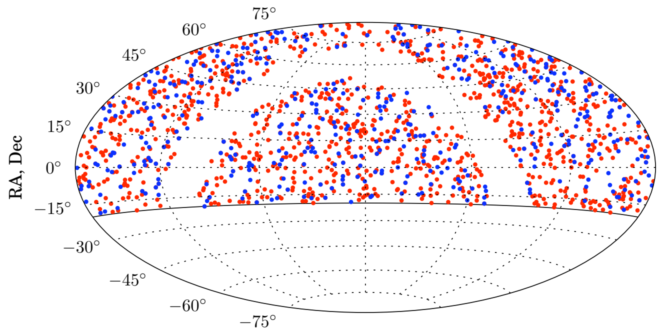
Locating the gamma-ray emission site and radio variability of blazars

- Problems:
  - Where does the gamma-ray emission originates in blazars?
  - What characterizes Fermi detected blazars as viewed in radio?

- Strategy:
  - Study radio and gamma-ray light curves for a large number of sources
    - Large sample of objects
    - Preselected as gamma-ray candidates
    - Observed independently of gamma-ray state
    - High cadence, observed twice per week
    - Robust statistical tests

OVRO 40 m Telescope
Blazar monitoring program

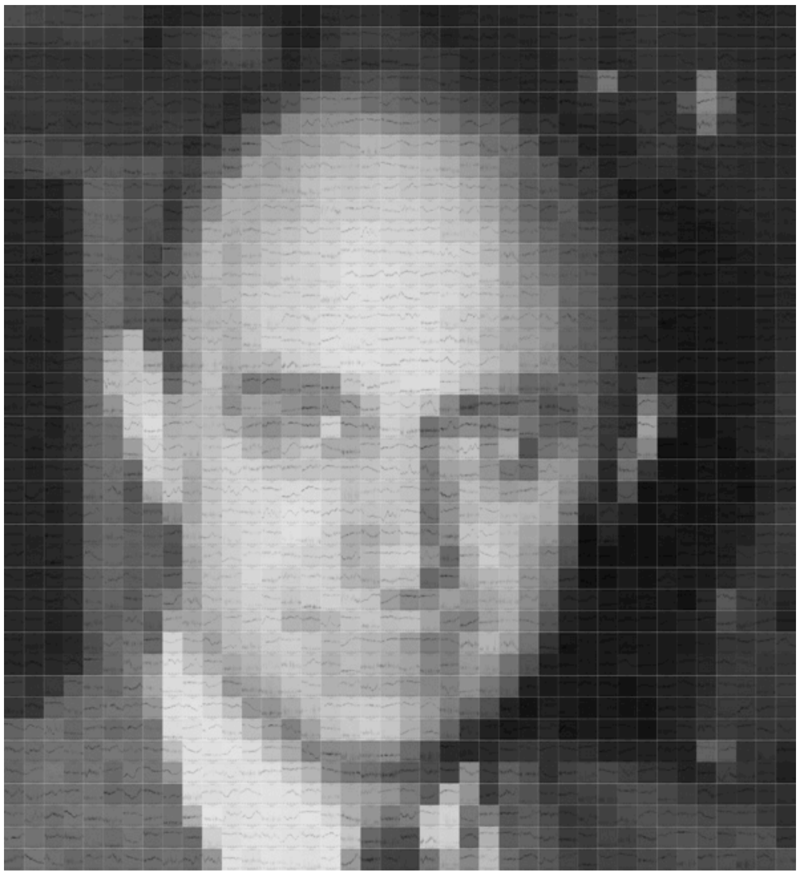
- Monitoring 1550 blazars
- 454 detected by Fermi on 1LAC “clean” sample
- Radio continuum 15 GHz, 3 GHz bandwidth
- 4 mJy thermal noise, ~3% typical uncertainty

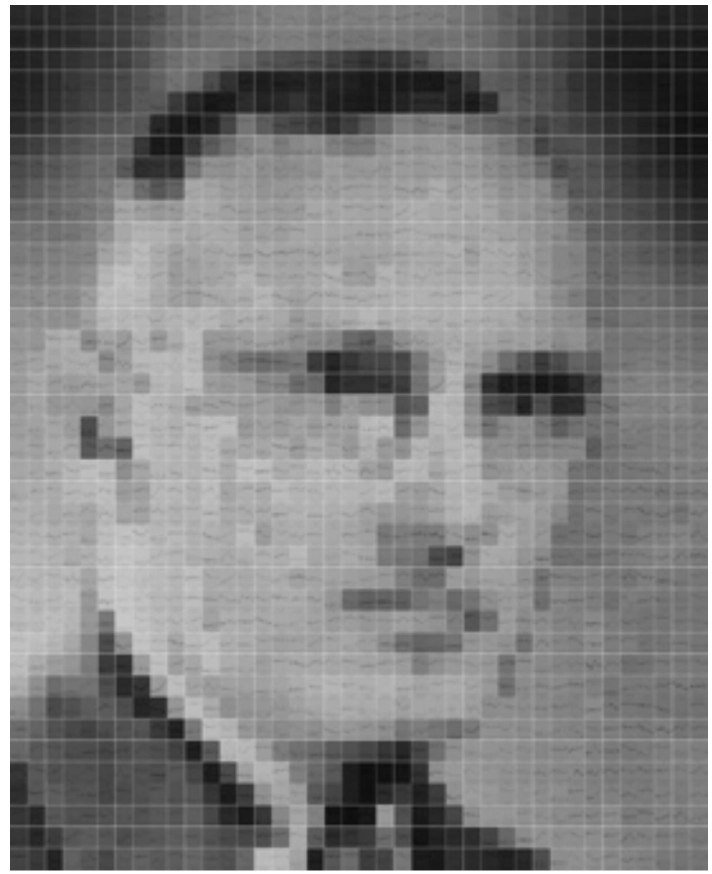


Distribution of CGRaBS sources in equatorial coordinates.
Red circles CGRaBS, Blue circles 1LAC

The OVRO 40 m Telescope at night
By Joey Richards

Our radio light curves:
A better picture of Fermi and Jansky





Our radio light curves:
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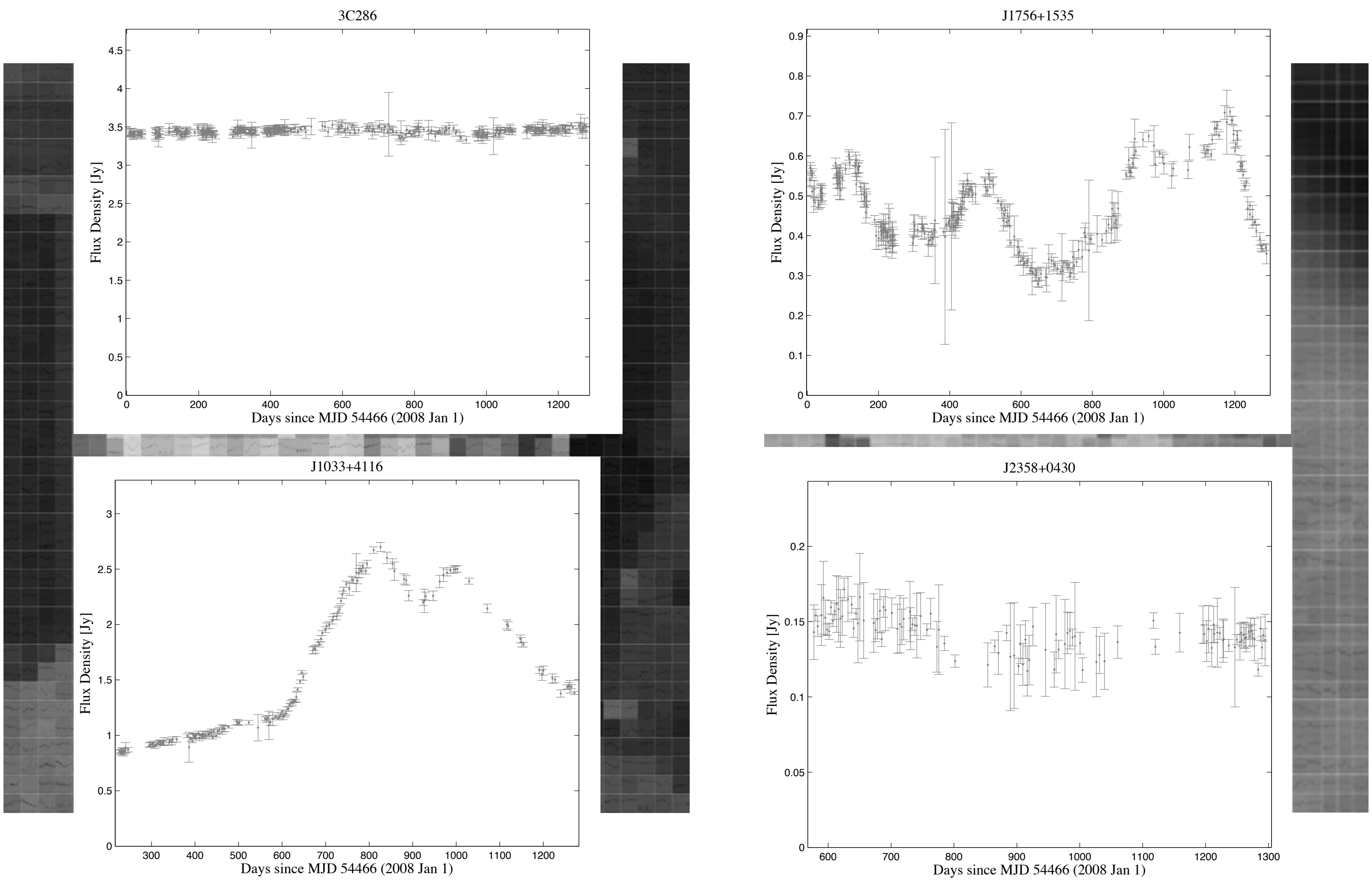
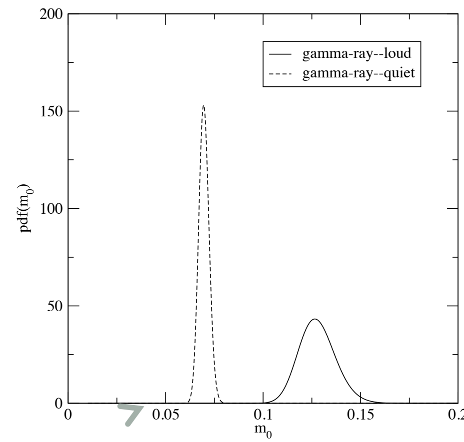
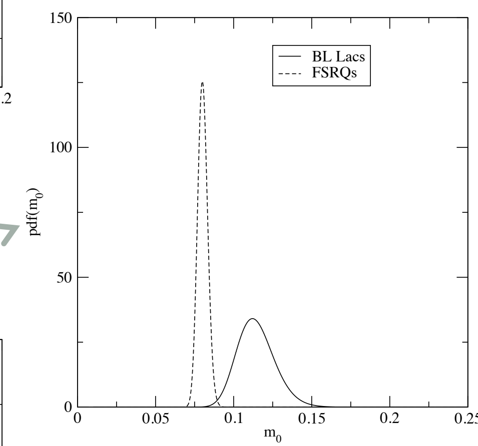
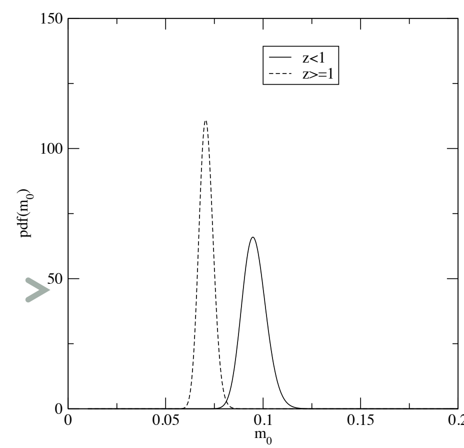


First results of the monitoring program: 2 years of data

- First data release, 2 years of data for original CGRaBS sample
- Radio variability properties studied using "intrinsic modulation index" m=σ/S
  - Gamma-ray detected sources are more variable in radio than non-detected ones
  - BL Lacs are more variable in radio than FSRQs
  - Low redshift FSRQs are more variable than high redshift ones



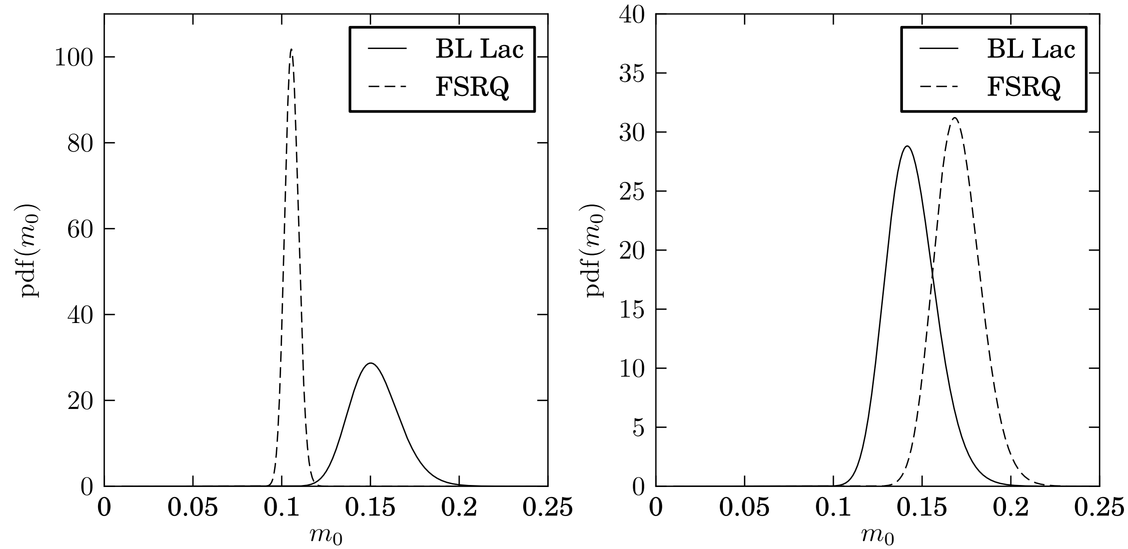




Richards et al 2011 ApJS, 194, 29

An update on radio variability properties: 3.5 years of data

- Gamma-ray detected still more variable than non-detected
- BL Lacs vs FSRQs



1LAC sources

CGRaBS sources

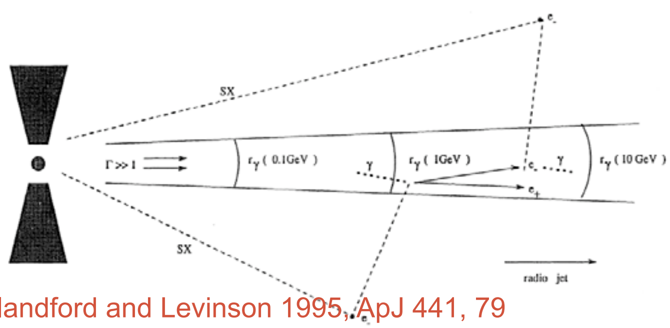
- Well defined samples are required to study population properties

- Redshift trend still there but less significant

Correlated radio and gamma-ray variability:
Constraining the location of the gamma-ray emission

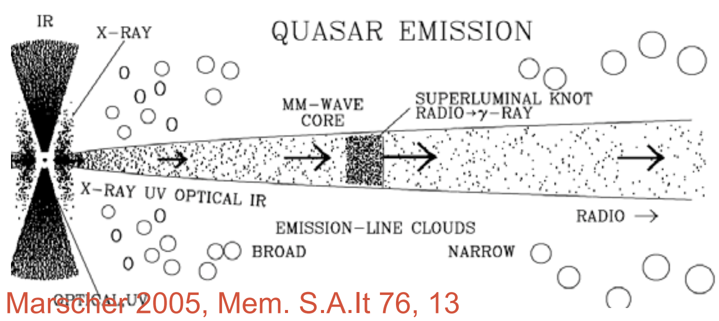
- Where in the jet are the gamma-rays produced?

- Close to central engine < 1 pc



Blandford and Levinson 1995, ApJ 441, 79

- Further down the jet, a few parsecs



Marscher 2005, Mem. S.A.It 76, 13

Results for brightest Fermi detected sources

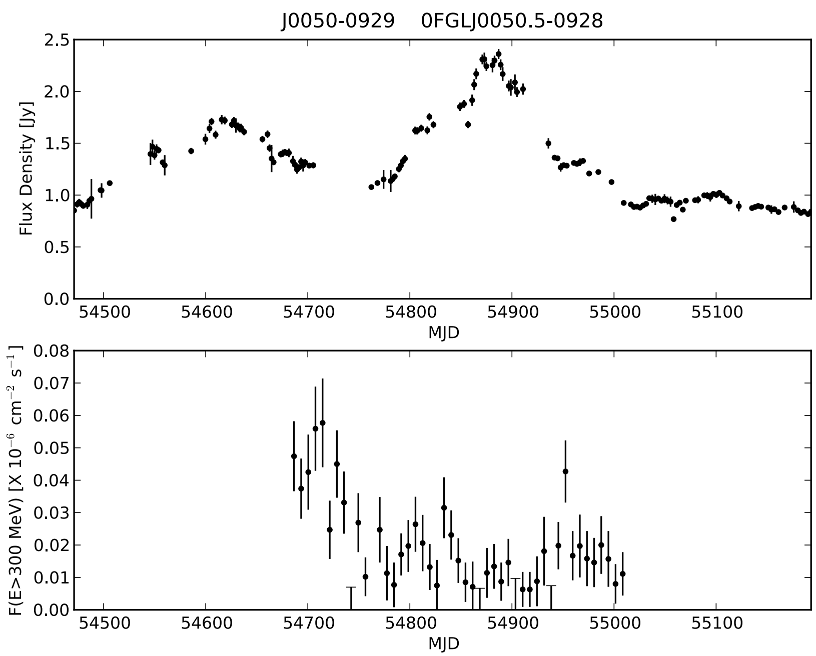
- Radio data
  - 2 year light curves of CGRaBS + a few calibrators
  - Published in Richards et al 2011, ApJS 194, 29
- Gamma-ray data
  - Published by Fermi collaboration on blazar variability paper. Abdo et al. 2010, ApJ 722, 520
  - 106 sources
  - 11 month light curves, weekly sampling
  - 52 / 106 are in CGRaBS and have simultaneous radio data

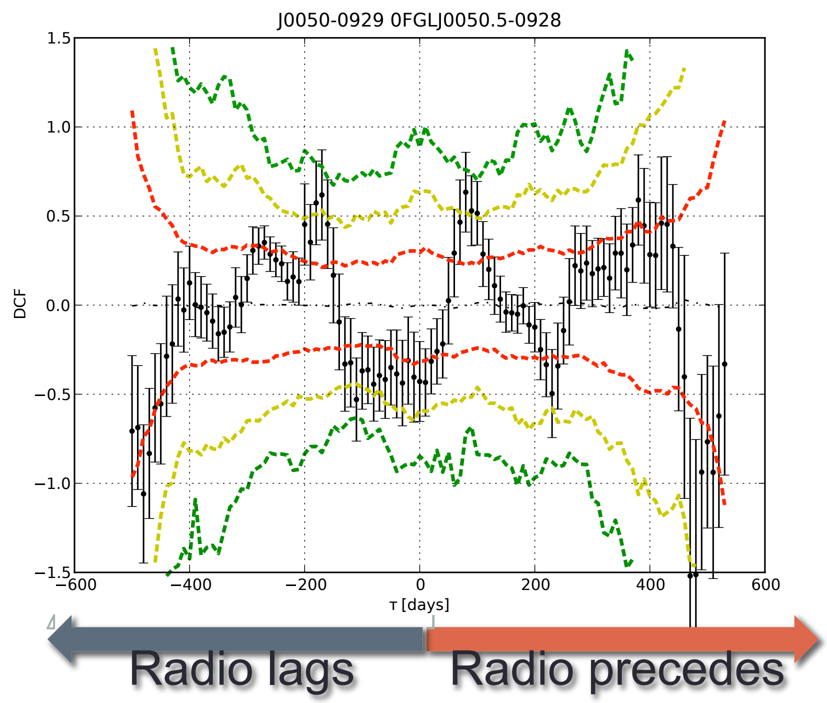
Radio/gamma-ray time lags and their significance

- Example cross-correlation. 3-month Fermi detections, using 11-months of Fermi data and 2 years of radio monitoring

○ Significance evaluated using simulated data with a power-law PSD ~ 1/f^β

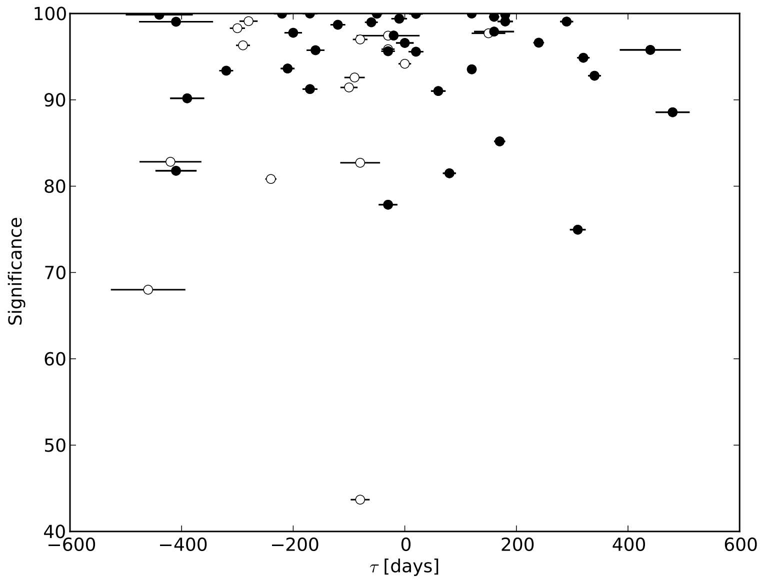
β_radio = 2.0, β_gamma = 1.5



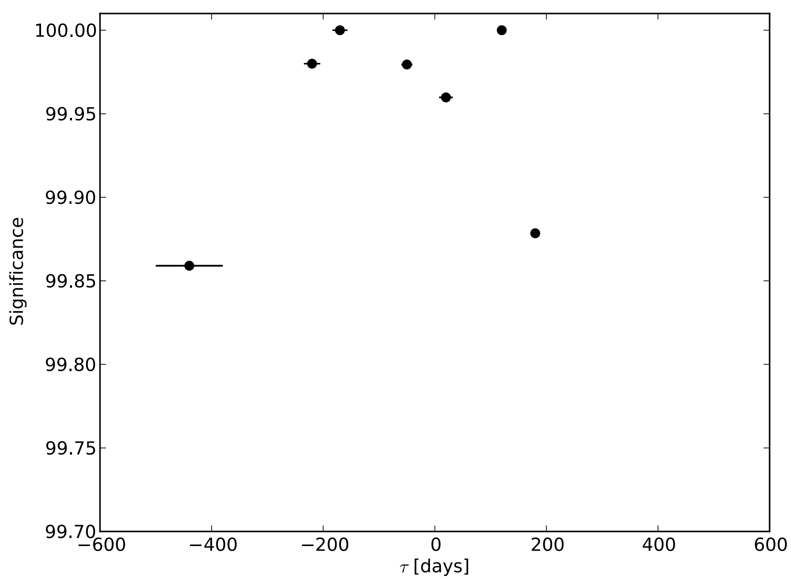


- **Only 7 out of 52 sources show significant correlations!**

Time lags and significance



All sources



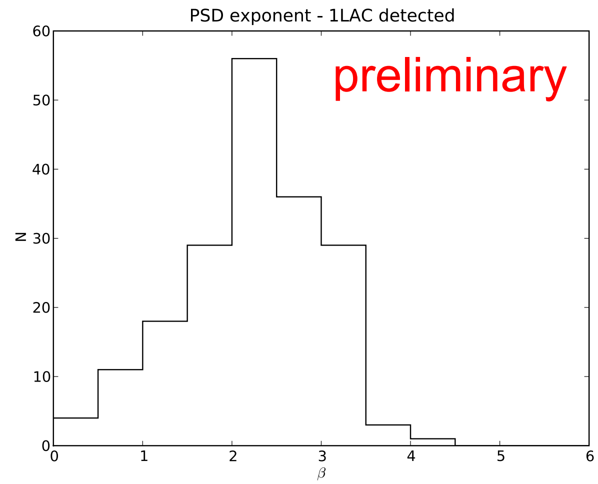
> 3σ significance

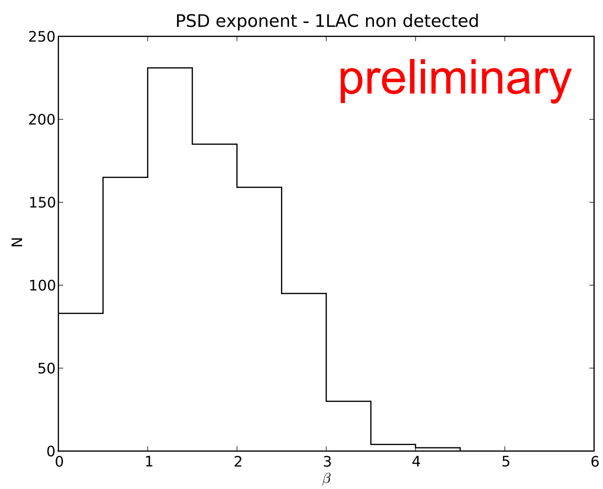
LAT Name	CGRaBS name	Optical class	SED class	τ days	significance %	uncertainty %
0FGLJ0050.5-0928	J0050-0929	BLLac	ISP	-170.0 ± 13.0	>99.98	0.0
0FGLJ0238.6+1636	J0238+1636	BLLac	LSP	-50.0 ± 10.0	99.98	0.02
0FGLJ0712.9+5034	J0712+5033	BLLac	ISP	-220.0 ± 15.0	99.98	0.02
0FGLJ0855.4+2009	J0854+2006	BLLac	LSP	-440.0 ± 60.0	99.86	0.05
0FGLJ1218.0+3006	J1217+3007	BLLac	HSP	120.0 ± 7.0	>99.98	0.0
0FGLJ1719.3+1746	J1719+1745	BLLac	LSP	180.0 ± 5.0	99.88	0.05
0FGLJ2254.0+1609	J2253+1608	FSRQ	LSP	20.0 ± 12.0	99.96	0.03

preliminary

Radio power spectral density

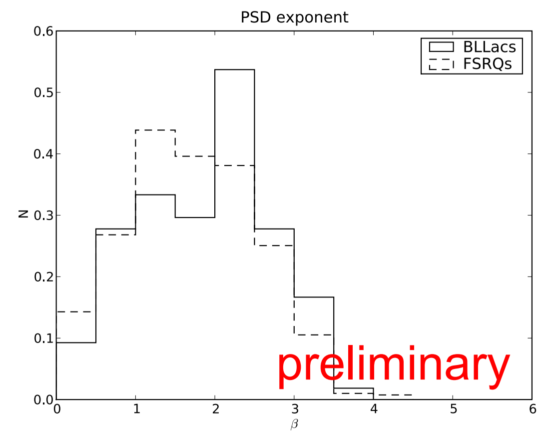
Detected vs non-detected





- Gamma-ray detected sources have steeper power spectral densities
- No clear difference for the case of BL Lacs vs FSRQs
- What will happen with longer radio time series?

BL Lacs vs FSRQs



We use Uttley et al 2002, MNRAS 332, 231, with some modifications

What is ahead?

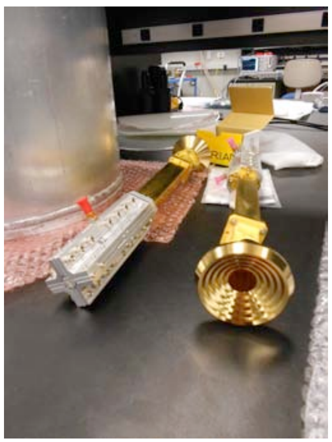
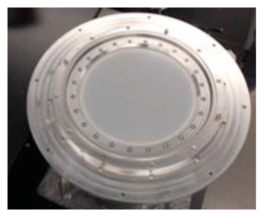
- Longer time series in radio and gamma-ray for more sources
  - Population studies
  - Individual source variability. More flares on each one
  - PSD characterization, populations, breaks, other models for light curves

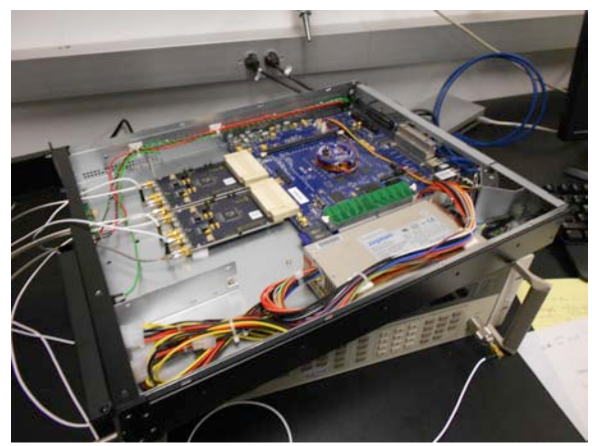
- Polarization monitoring

- Optical monitoring

Polarization monitoring: KuPol

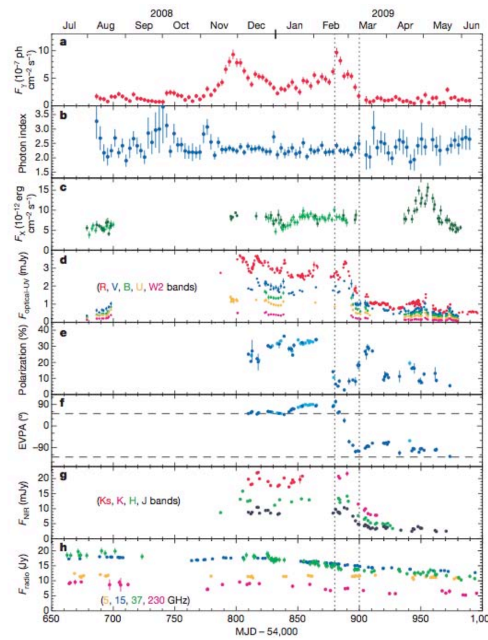
- Polarization probes the structure of magnetic fields in emission region
- KuPol a new receiver in the 12 to 18 GHz band

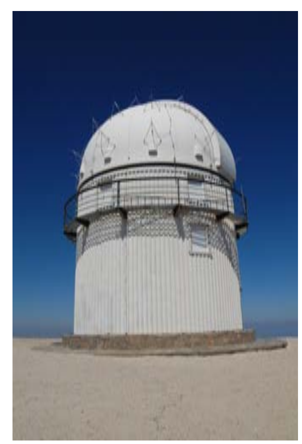



Optical monitoring: RoboPol

- Aim: high-cadence monitoring of linear polarization of a large (~100) sample of blazars
- Automated observing, dynamic observing schedule capable of responding to changes in a source
    - Goal: high-cadence light curves of polarization events
- Will use the Skinakas 1.3 m telescope at U. Crete
- Polarimeter is funded and under construction
- Observations to start in the Northern summer of 2012
- Participating institutions are: Caltech, MPIfR, Torun, U. Crete/FORTH and IUCAA



3C 279
Abdo et al. 2010, Nature 463, 919



Skinakas 1.3m telescope U. Crete

Summary

- Using high cadence radio and gamma-ray light curves we study the connection between radio and gamma-ray emission in Fermi detected blazars
- We find that 7 out of 52 sources studied have 3σ significant correlations
- The significance depends on the model for the light curves => robust methods to characterize them are required
- Polarization monitoring will start observing next year
  - Radio with KuPol
  - Optical with RoboPol